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ABSTRACT

This paper presents results of a LISREL factor analysis on data from the Wechsler Intelligence Scale for Children-Revised (WISC-R) and the Wechsler Intelligence Scale for Children-Chinese Revised (WISC-CR) (published in 1986) for children ages 6.5 to 16.5 years, using a standardization sample of 200 children (100 males and 100 females) at each of the 11 age levels (2,200) for the WISC-R and 2,237 children for the WISC-CR. The same best fit common factor structure was found for the WISC-R and the WISC-CR. The common factor structure included three factors tentatively labeled verbal comprehension, perceptual organization, and freedom from distractibility. In addition, a multi-sample LISREL analysis was performed to test the equality of the factor pattern between age groups and between the two cultures. Both American and Chinese children in the oldest and youngest ranges of age groups fit the common factor structure better than did other age groups. Those age groups that best fit the common factor structure also showed high factor pattern consistency between the cultures. It is argued that ability and model fit differences may be linked to differences in cultural and educational experiences. Seven tables and three graphs illustrate the analyses. There is an 11-item list of references. (Author/SLD)

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FACTOR ANALYSIS OF THE WISC-R AND WISC-CR:

A COMPARISON ACROSS AGES BETWEEN AMERICAN AND CHINESE SAMPLES

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FACTOR ANALYSIS OF THE WISC-R AND THE WISC-CR: A COMPARISON ACROSS AGES BETWEEN AMERICAN AND CHINESE SAMPLES

Abstract

This paper presents the results of a LISREL factor analysis on data from the WISC-R and the WISC-CR (Chinese Revised) for children ages six and one-half to sixteen and one-half years. The same best fit common factor structure was found for the WISC-R and the WISC-CR. The common factor structure included three factors tentatively labeled Verbal Comprehension, Perceptual Organization, and Freedom from Distractibility. In addition, a multi-sample LISREL analysis was performed to test the equality of the factor pattern between age groups and between the two cultures. Both American and Chinese children in the youngest and oldest ranges of age groups fit the common factor structure better than other age groups. Those age groups which best fit the common factor structure also showed high factor pattern consistency between the cultures. It is argued that ability and model fit differences may be linked to differences in cultural and educational experiences.

Background

The Wechsler Intelligence Scale for Children-Revised (WISC-R) was factor-analyzed at ages 6½ to 16½ by Kaufman (Kaufman, 1975). A principal-components analysis, followed by varimax rotation of factors with eigenvalues greater than 1.0, was performed. Kaufman advocated a three-factor structure, identifying the factors as Verbal Comprehension, Perceptual Organization, and Freedom from Distractibility for 11 age groups.

The standardization of the Wechsler Intelligence Scale for Children-Chinese Revised (WISC-CR) was published in 1986. A principal-components analysis was done by Chinese researchers Dai, Lin, and Zhang (1990). The data followed Kaufman's three-factor structure, and that structure was consistent across the 11 age groups.

Purpose

Factor analysis provides important information for interpretation of results from intelligence tests. It is also important that the factor structure of the WISC-R and the WISC-CR be well understood before the next revisions of these tests are initiated.

Both Kaufman (1975) and Dai et al. (1990) performed only principal-components analysis across all age groups. Neither study included a multi-sample analysis to test how well the three-factor model fit different age groups. Nor did either study attempt to link the factor pattern matrices

by use of targeted rotations. In contrast, LISREL methods used in the present study provide tests of the goodness of fit of the common factor structure for each of the individual American and Chinese age groups. The factor pattern comparisons, with the multiple-group analyses, are made between the same age groups for Chinese and American children and among the eleven age groups for both American and Chinese samples. Possible reasons for the differences found in the common factor structure fit between the two cultures and across age groups are also discussed.

Method

Instruments

The WISC-R includes 12 tests (10 mandatory, 2 optional), which are: Information (I), Similarities (S), Arithmetic (A), Vocabulary (V), Comprehension (C), Digit Span (DS), Picture Completion (PC), Picture Arrangement (PA), Block Design (BD), Object Assembly (OA), Coding (CD), and Mazes (MA). The first six tests comprise the Verbal Scale while the latter six tests comprise the Performance Scale.

The WISC-CR (Lin & Zhang, 1986) was developed from the WISC-R. However, during the revision, some changes were made in the Verbal Scale. The most significant changes occurred in the Information test (about half of the items were rewritten), because the knowledge needed to answer the items was specific to American culture. In addition, one more

difficult item was added to the Arithmetic test, and two harder items were added to the Digit Span test. These changes were made because the tests appeared too easy for Chinese children. There were no significant changes made to the Performance Scale, except that items on the Picture Completion and the Picture Arrangement were redrawn. A pretest was administered to a pilot group (N = 1833) and an item analysis was performed in 1980 (Lin & Zhang, 1986). After some item revision, the WISC-CR standardization was begun in 1982 and completed in 1985, with tests administered across all of China. As a result, the WISC-CR was published in 1986.

Subjects

The WISC-R standardization sample included 200 children (100 boys and 100 girls) at each of 11 age levels from 6½ to 16½ years (N = 2200). Each child was tested within six weeks of his midyear (i.e., children aged 6½ were no younger than 6 years 4 months 15 days and no older than 6 years 7 months 15 days).

The WISC-CR standardization sample included 2237 children, about 200 at each of 11 age levels from 6½ to 16½ years. Unlike the WISC-R, each WISC-CR age level was over the entire age category (i.e., 6½ included 6 years 0 month 1 day to 6 years 11 months 30 days).

Procedure

(1). Definition of model.

In previous studies of the WISC-R and WICS-CR, both American and Chinese researchers advocated using a principal-components analysis with correlation matrices, and the three-factor structure for all 11 age groups of each culture. In this study, a best fit common model was defined for these cultures and ages. Some comparison between cultures and ages were then made. As correlation matrices do not contain all the relevant information (Mcdonald, 1985; Mulaik, 1972), the sample covariance matrices from each sample were computed. A confirmatory factor analysis (Jöreskog & Sörbom, 1986) was performed on covariance matrices for both the WISC-R and the WISC-CR standardization samples for each age level. The best fit factor models for each individual age group were then determined. Since the models had obvious similarities, one common factor structure was found for the 11 American age levels. This was the best fitting model for nine American age groups and close to the best fitting models for the other age groups. The same common factor structure was found for the 11 Chinese age levels. This was the best fitting model for three Chinese age groups and was slightly different from the best fitting models for the other age groups.

(2). Factor pattern comparison between ages.

The American age 6½ (best fit for the common model) was chosen as the target group for a multi-sample comparison

with other American age groups (see Jöreskog & Sörbom, 1986; Hayduk, 1987). The Chinese age 8½ (best fit age group) was chosen as the target to compare with other Chinese age groups.

(3). A comparison of Factor pattern between cultures.

A multi-sample analysis was performed with each American age group as the target to test the equality of factor pattern between the two cultures (e.g., Chinese age 6½ compared with American age 6½).

(4). A comparison of the performance between cultures

In order to understand the differences in the fit to the common model, the Scaled Score Equivalents of Raw Scores tables (Wechsler, 1974; Lin & Zhang, 1986) were examined and compared to the raw scores between cultures.

Results and Discussion

The best fit model for each individual age group was found using a LISREL factor analysis. There were slight differences between ages. The range of the goodness-of-fit indices (GFI) was .93 to .96, with the adjusted goodness-of-fit indices (AGFI) ranging from .89 to .94. The results of the chi-square test showed that for most age groups of both cultural samples there was adequate fit.

The common factor structure was the same as Kaufman obtained in his principal-factor analyses (Table 1). This means that each test did not necessarily measure only one factor. For example, Information and Arithmetic measure both

Verbal Comprehension and Freedom from Distractibility factors; Picture Completion and Picture Arrangement measure both Verbal Comprehension and Perceptual Organization factors (using Kaufman's labels for these factors); on the other hand Similarities, Vocabulary, and Comprehensive measure only the Verbal Comprehension factor; Block Design, Object Assembly, and Mazes measure only the Perceptual Organization factor; and Digit Span and Coding measure only the Freedom from Distractibility factor (Kaufman, 1975; Sattler, 1988). Although these results fit what we called Kauufman's overlap model, Kaufman preferred the non-overlap model, which assumes that one test measures only one factor. In the non-overlap model, Information, Similarities, Vocabulary, and Comprehensive were hypothesized to measure factor A; Picture Completion, Picture Arrangement, Block Design, Object Assembly, and Mazes to measure factor B; Arithmetic, Digit Span, and Coding to measure factor C. A confirmatory factor analysis showed that Kaufman's non-overlap model was not a best fitting model for any of the ages in either culture. The overlap model was the best fitting model for nine of the eleven American age groups and for three of the eleven Chinese age groups. A statistical test of the difference between Kaufman's non-overlap model and the overlap model which chosen for the target samples in the American and Chinese groups reinforced this conclusion. The overlap model fit the data significantly better than did the non-overlap model (American age 6½ group, chi-square

equals 85.09, df = 4 and p < .001; Chinese age 8½, chi-square equals 71.86, df = 4 and p < .001). Therefore, the overlap model was chosen as the common factor structure model in this study.

Insert Table 1 about here

The GFI of the common model for the American sample ranged from .931 to .958 and the AGFI ranged from .888 to .931 (Table 2). The chi-square test results indicate that ages 6½ and 8½ fit the common model quite well. Ages 7½, 10½ and 16½ fit the common model better than the remaining age groups. The test for multi-sample analysis of equality of factor pattern, with age 6½ as the target group, found that the overall chi-square for the 11 American age groups was 776.98 (df = 517, p < .001). Using the same technique to look at individual age groups, resulted in no significant differences between the American target group and ages 7½, 8½, 10½, 12½ and 16½ (p values of chi-square test greater than .01, see Table 3).

Insert Table 2 & 3 about here

The GFI of the common model for the Chinese sample showed that the GFI ranged from .928 to .958 and the AGFI ranged from .882 to .928 (Table 4). The chi-square test indicated that ages 8½, 9½, and 16½ fit the common model best. Ages 7½ and 15½ fit the common model better than the other age groups. The test for multi-sample analysis of equality of factor pattern, with age 8½ as the target group, revealed that the overall chi-square for the 11 Chinese age groups was 802.13 (df = 517, $p < .001$). Using the same technique to look at individual age groups resulted in no significant differences between the Chinese target group and ages 7½, 9½, 15½ and 16½ (p values of chi-square test greater than .01, see Table 5).

Insert Table 4 & 5 about here

In the age-matched comparison between American and Chinese samples (Table 6), the chi-square tests for the equality of factor pattern showed that ages 6½, 8½ and 16½ had higher consistency between cultures. The consistency of the pair for age 7½ was higher than the other seven age pairs.

Insert Table 6 about here

Both American and Chinese results showed that the youngest range of age groups (ages 6½ to 8½) and oldest age groups (age 16½) fit the common model better and had higher consistency on the factor patterns between cultures than the other age groups. Some researchers have explained this pattern as intelligence differentiation (Hong, 1988). Hong purports that the intelligence of young children is general, and that with development, ability becomes more and more specific. One consideration is that generalization and differentiation are functions of education. Before going to school, children have dissimilar learning experiences and consequently use different abilities to solve problems. After 1 to 2 years in a relatively formal educational setting, they use similar intellectual resources to solve problems. Chinese children typically go to school at age 7; many of them never go to kindergarten or preschool. Our research shows that the Chinese age group 8½ fits the common model best. With American children the best fit is for the 6½ age group, one reason for this may be the common preschool and kindergarten experiences American children have. After the first few years of study, as children learn more and their knowledge increases, it is more likely that they use different abilities to solve problems. At sixteen, an individual's general ability improves from a multitude of performance training sources, and as they become more knowledgeable, they become better at selecting the best way

to solve problems. Consequently, the oldest age group fits the common model better than the middle range of age groups.

Comparing the individual with the common age group model, the largest differences in age groups were found for both the American and Chinese samples on Arithmetic, Picture Completion and Picture Arrangement. The following tests for the given age groups did not belong to the Verbal Comprehension factor: Arithmetic for Americans ages 9½ and 12½, and Chinese ages 6½, 7½, 13½, and 14½; Picture Completion for Americans ages 9½ and 12½ and Chinese ages 10½, 13½, and 14½; Picture Arrangement for Americans ages 12½ and Chinese ages 10½, 13½, and 14½. Those differences happened at various age levels of both cultures. We believe that some of the tests measure different abilities for the different ages regardless of membership in a particular culture. For the Chinese older age groups, Mazes belonged to the Freedom from Distractibility, while for the American children, it did not.

Insert Table 7 and Figure 1, 2 & 3 about here

Table 7 shows a performance comparison between cultures. The Chinese sample has higher ability levels in Arithmetic, Vocabulary, Digit Span, Block Design (Figure 3) and Coding B (for children 8 and old). For example, Chinese children age eight and one-half could do Digit Span as well

as American children sixteen and one-half. Chinese children were one to five years more advanced in Arithmetic performance than American children (Figure 1). Chinese children performed Object Assembly less well than American children across most age groups (Figure 2). Other tests favored a particular culture for particular age groups. Compared to the American norm, younger Chinese age groups did Picture Completion less well, older Chinese age groups did Information better; older Chinese age groups did Picture Arrangement less well. Those kinds of test item difficulty differences across cultures may be one of the causes of common model fitting differences. As with the WISC-CR results, the WAIS-CR results showed that the Chinese adult sample had higher performance on Arithmetic and Digit Span and lower performance on Object Assembly than the American adult sample (Lin, 1985). For the Digit Span test, we need to consider a word-length effect in interpreting culture differences (Baddeley, 1992). Some digits in English tend to have long vowel sounds or more than one syllable which may take longer to rehearse than in Chinese. Also, mastering knowledge plays a very important part within the Chinese education. Chinese put a great emphasis on memory and calculation training. Children in China have little chance to work with puzzles.

Conclusion

The three factor structure model has been shown to suit

both the WISC-R and the WISC-CR. The following common factor model was found for both WISC-R and WISC-CR: Information, Similarities, Arithmetic, Vocabulary, Comprehension, Picture Completion and Picture Arrangement measured Verbal Comprehension; Picture Completion, Picture Arrangement, Block Design, Object Assembly and Mazes measured Perceptual Organization; and Information, Arithmetic, Digit Span and Coding measured Freedom from Distractibility. The youngest and oldest ranges of age groups fit the common model better than the other age groups for both cultures and also, had higher consistency on the factor pattern between the two cultures. Educational experiences may be the major cause of the ability and model fitting differences across ages between cultures.

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Table 1
The Simple Structure of Common Factor Structure Model

Tests	Factor Load		
I	1	0	1
S	1	0	0
A	1	0	1
V	1	0	0
C	1	0	0
DS	0	0	1
PC	1	1	0
PA	1	1	0
BD	0	1	0
OA	0	1	0
CD	0	0	1
MA	0	1	0

Table 2
The Common Factor Structure Model for 11 American Age Groups

Age	GFI	AGFI	Chi-sq (df=47)	P
6½	.958	.931	53.01	.254
7½	.953	.922	62.12	.069
8½	.957	.928	53.04	.253
9½	.937	.896	83.96	.001
10½	.951	.918	63.33	.056
11½	.941	.903	76.92	.004
12½	.944	.907	74.22	.007
13½	.938	.897	80.67	.002
14½	.944	.907	74.68	.006
15½	.931	.888	91.69	.000
16½	.951	.918	63.34	.056

Note. GFI: Goodness-of-Fit Index.
AGFI: Adjusted Goodness-of-Fit Index.
Chi-sq: Chi-square.

Table 3
Test Equality of Factor Patterns Between Different American Age Groups

Age	GFI	Chi-sq (df=94)	P
6½	.958		
7½	.953	115.13	.069
8½	.957	106.05	.186
9½	.937	136.97	.003
10½	.951	116.33	.059
11½	.941	129.93	.008
12½	.944	127.49	.012
13½	.938	133.68	.005
14½	.944	127.79	.012
15½	.931	146.99	.000
16½	.951	116.35	.059

Note. The age 6½ as the target group with the common model.

Table 4
The Common Factor Structure Model for 11 Chinese Age Groups

Age	GFI	AGFI	Chi-sq (df=47)	P
6½	.942	.902	76.85	.004
7½	.941	.901	72.22	.010
8½	.959	.932	54.15	.220
9½	.949	.916	54.74	.204
10½	.942	.904	77.25	.004
11½	.936	.893	83.06	.001
12½	.928	.896	90.67	.000
13½	.940	.901	77.75	.003
14½	.929	.882	99.28	.000
15½	.949	.917	61.21	.080
16½	.958	.928	54.95	.199

Table 5
Test Equality of Factor Patterns Between Different Chinese Age Groups

Age	GFI	Chi-sq (df=94)	P
6½	.942	129.82	.009
7½	.941	125.00	.017
8½	.959		
9½	.949	110.65	.116
10½	.942	132.49	.005
11½	.936	137.20	.002
12½	.928	153.91	.000
13½	.940	131.80	.006
14½	.929	152.49	.000
15½	.949	117.28	.052
16½	.958	106.75	.174

Note. The age 8½ as target group with the common model.

Table 6
Same Age Group of American and Chinese Children Factor Pattern Comparison

	American	Chinese		
Age	GFI	GFI	Chi-sq (df=94)	P
6½	.958	.942	128.68	.010
7½	.953	.941	133.48	.005
8½	.957	.959	107.19	.166
9½	.937	.949	140.51	.001
10½	.951	.942	141.71	.001
11½	.941	.936	159.98	.000
12½	.944	.928	169.21	.000
13½	.938	.940	158.70	.000
14½	.944	.929	179.26	.000
15½	.931	.949	154.95	.000
16½	.951	.958	116.28	.062

Note. Same age American group as the target group with the common model.

Table 7
American and Chinese Children Performance Comparison on The WISC-R and WISC-CR

	Ages					
Tests	6½	8½	10½	12½	14½	16½
I	6½	8½	11	14½	16½	16½
S	6	8	10½	12½	14	15½
A	7½	11½	15½	16½	16½	16½
V	6½	10	14	16½	16½	16½
C	7½	10	11½	13½	15½	16½
DS	11½	16½	16½	16½	16½	16½
PC	6	8	9½	11½	14½	16½
PA	6½	9½	10½	12½	13½	13½
BD	7½	10½	12½	13½	15½	16½
OA	6	6½	8½	9½	10½	10½
CD	6½	9½	12	14½	16½	16½
MA	6½	8½	10½	12½	14½	16½

Note. The top line shows Chinese ages, other lines in the table are American children's ages, which have same performance in the tests with the Chinese age group in the top line (e.g. the performance of the Chinese six and one-half on the A, equals the performance of American seven and one-half on A).

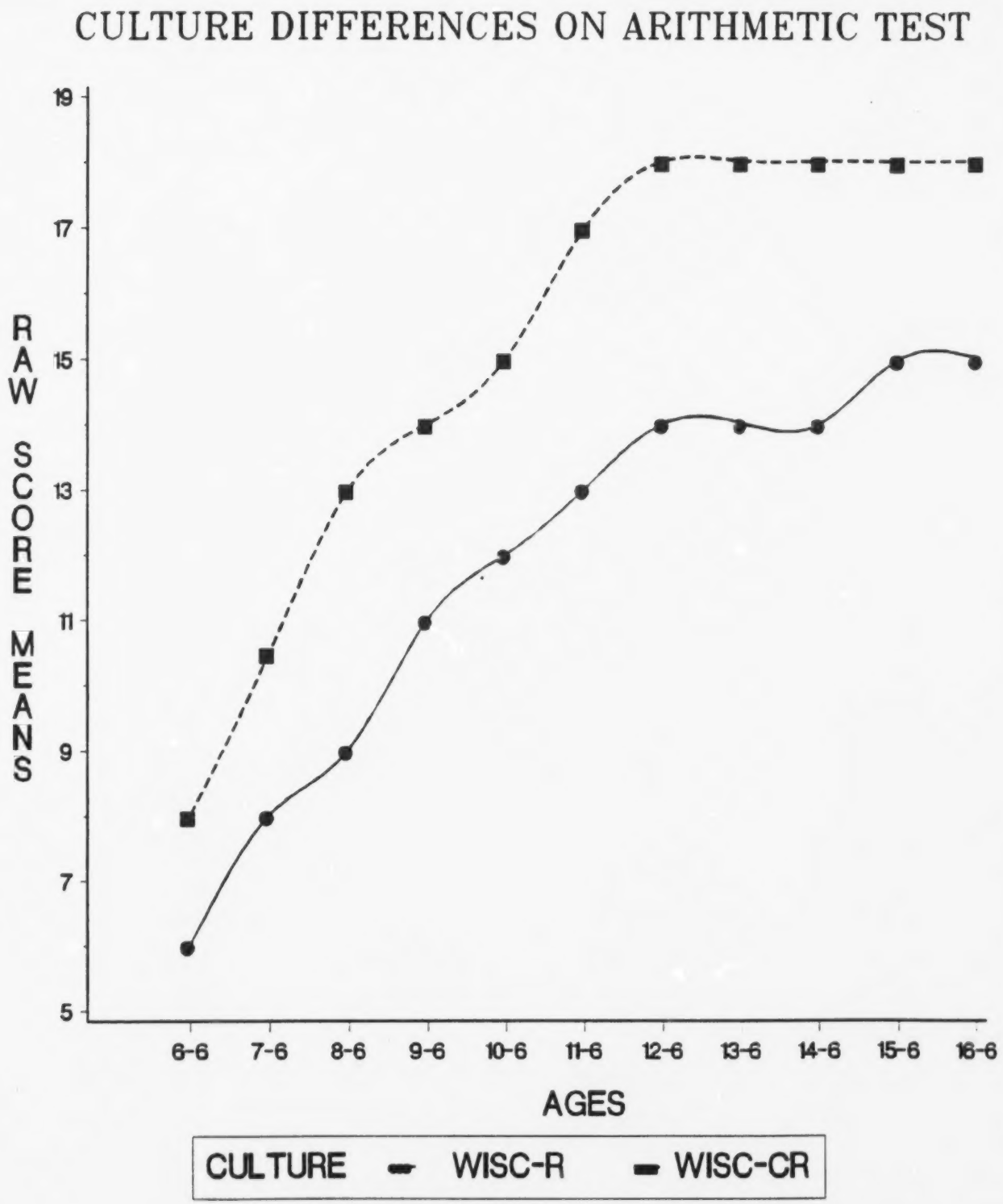

FIGURE 1. RAW SCORE COMPARISON ON ARITHMETIC TEST

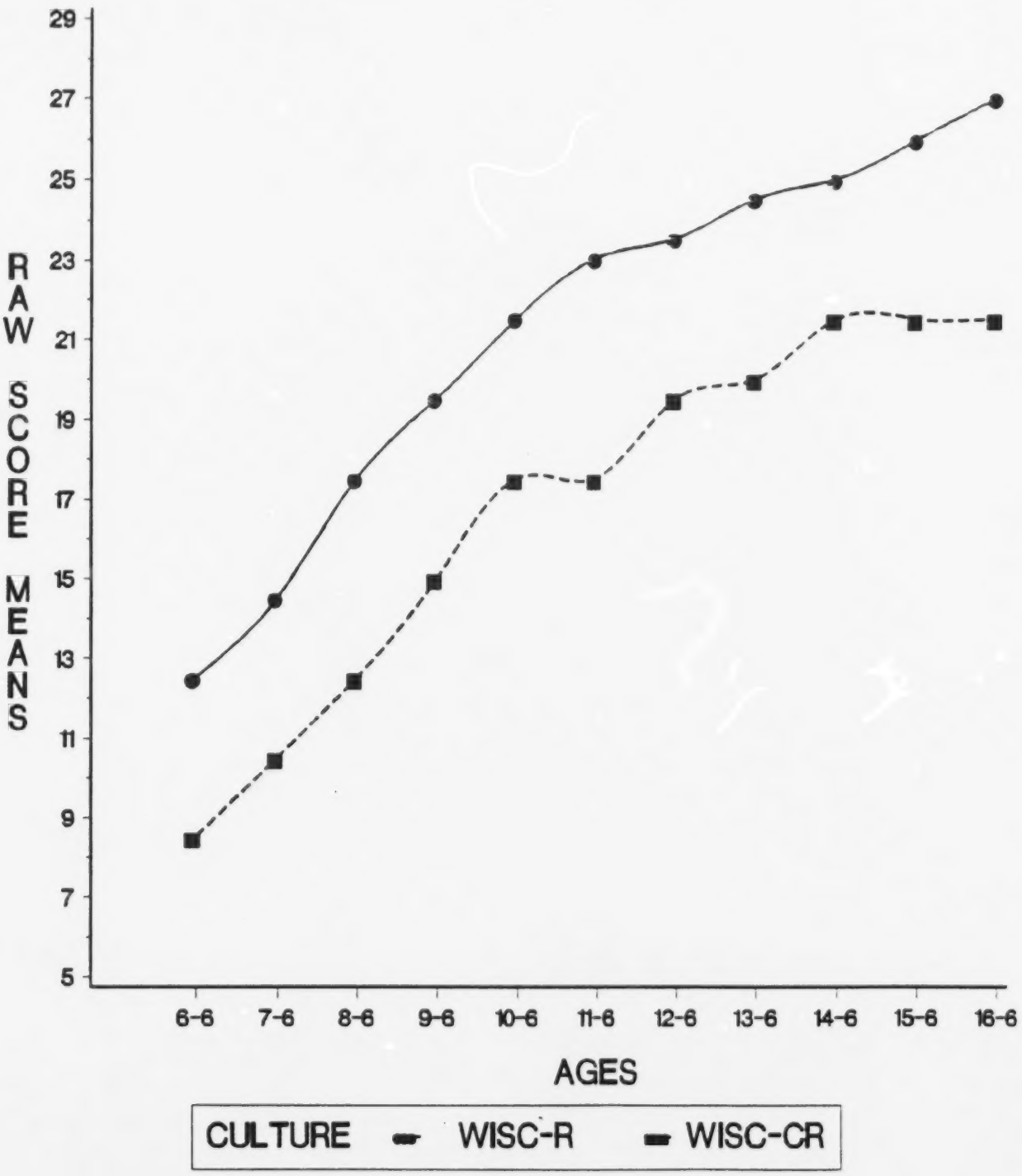

FIGURE 2. RAW SCORE COMPARISON ON OBJECT ASSEMBLY TEST

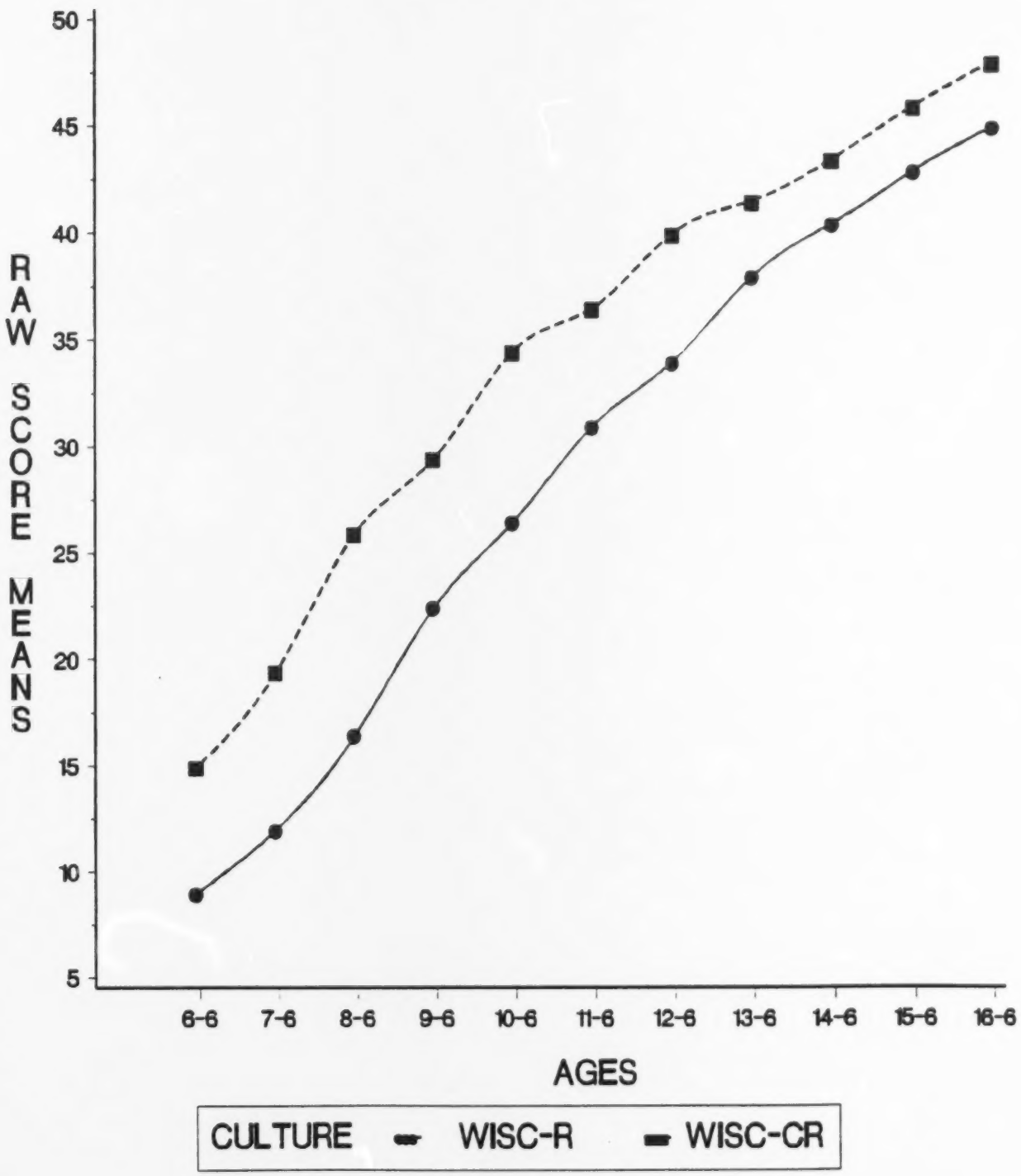

FIGURE 3. RAW SCORE COMPARISON ON BLOCK DESIGN TEST